Energy Assessment Strategy and Energy Concepts for Industrial Facilities

Industrial Process and Energy Optimization
Industry Workshop
Feb. 25-27, 2004 in Gettysburg, PA

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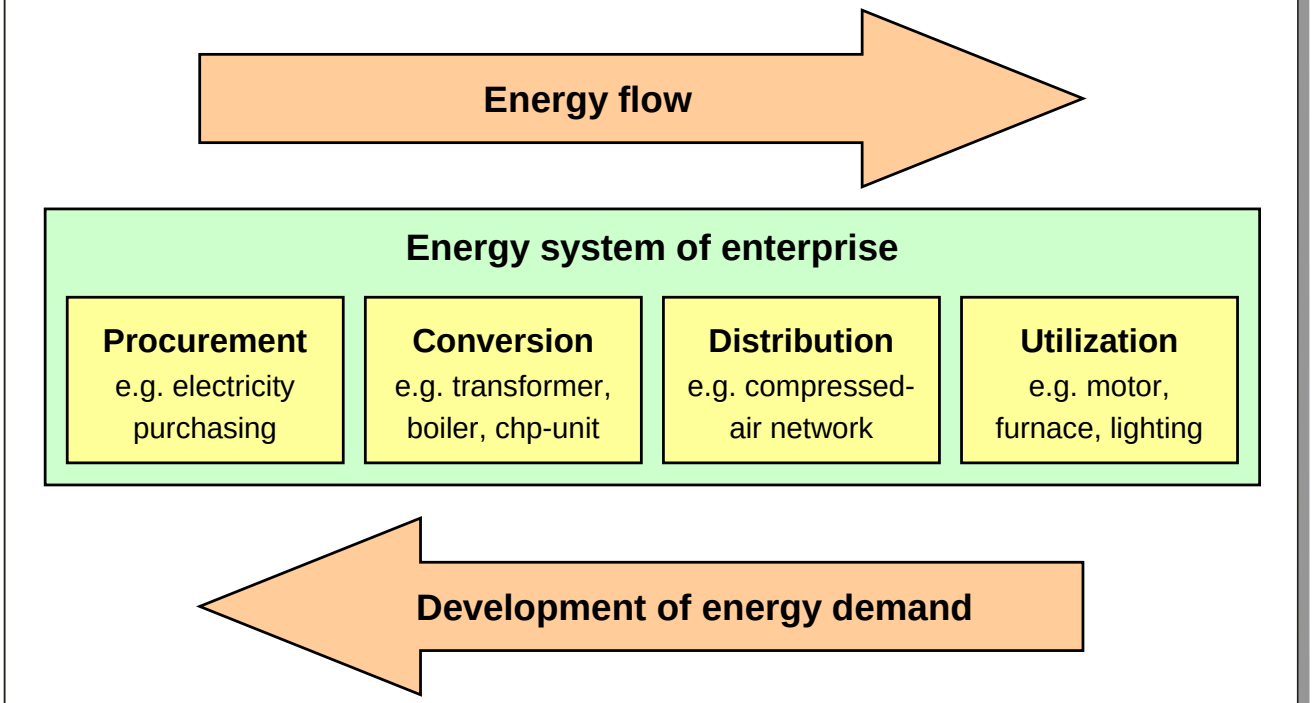
Energy system of an Enterprise



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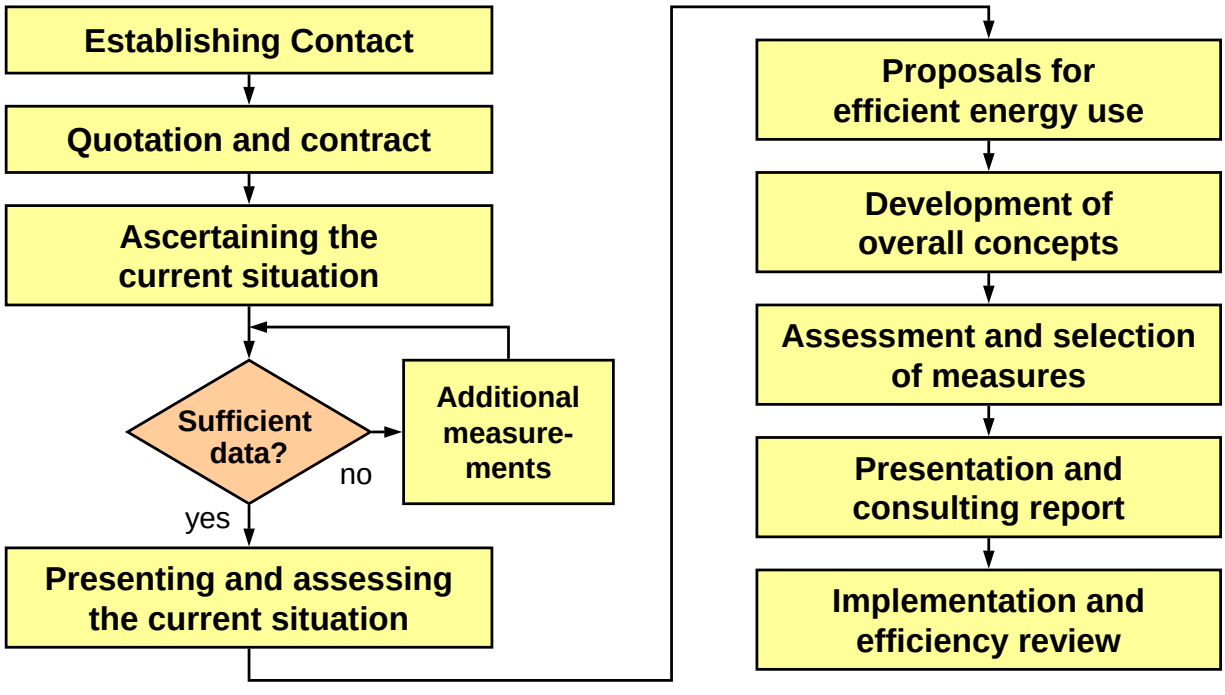
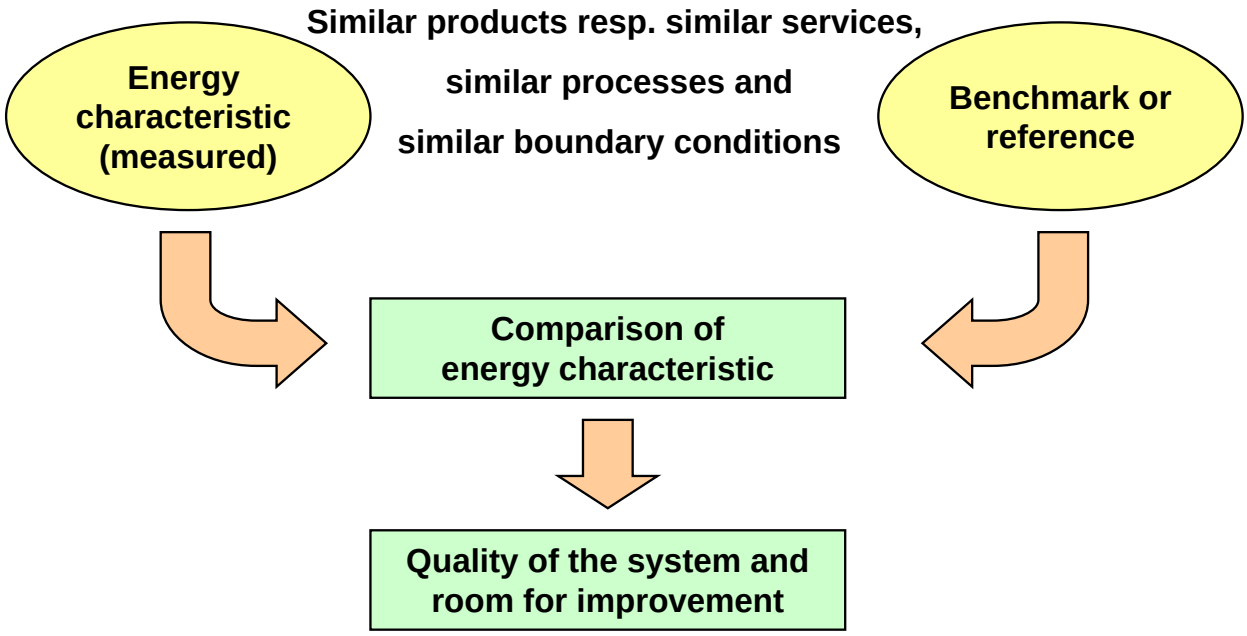
Energy Consultation Procedure



According to VDI 3922

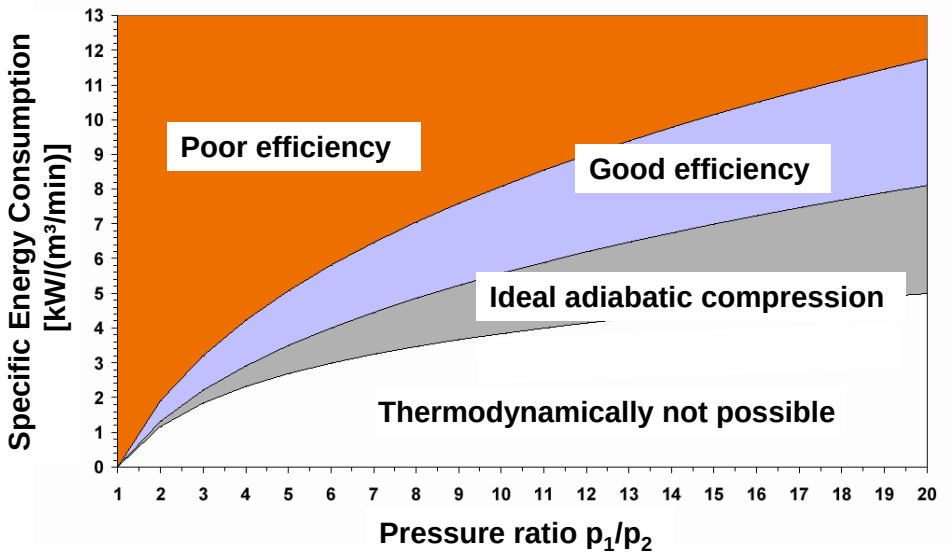
First Assessment of the Energy Efficiency



Layer et al. 1999

Example: Compressed-Air System

- Thermodynamic minimum
- Reference point: max. 45 % above adiabatic compression



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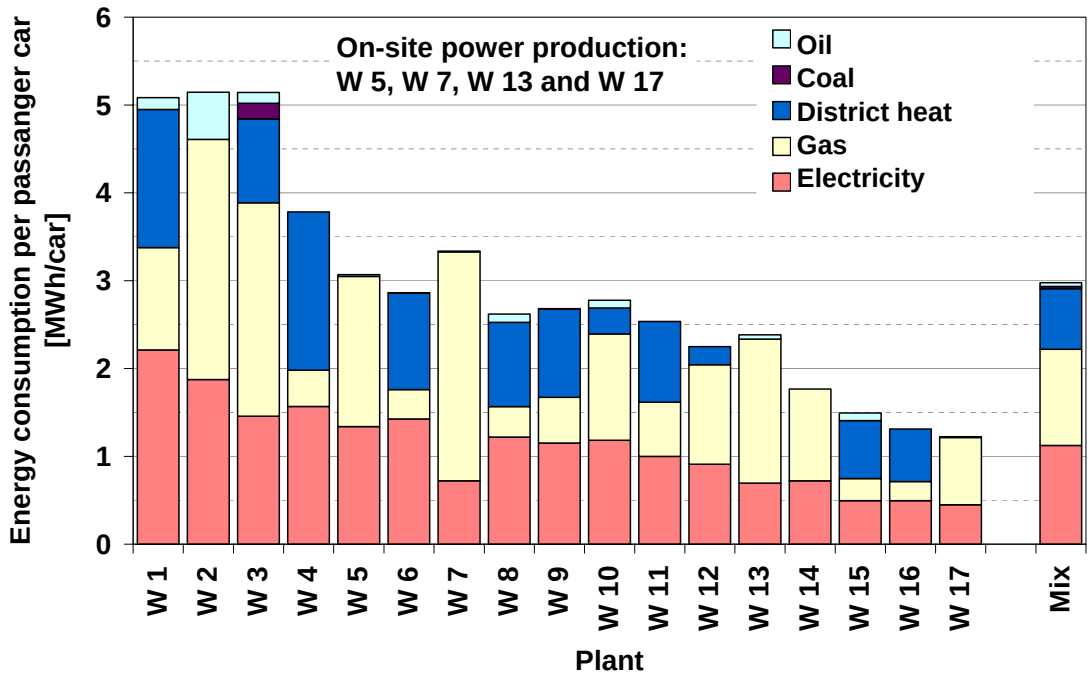
Example: Assembly Plant for Passenger Cars



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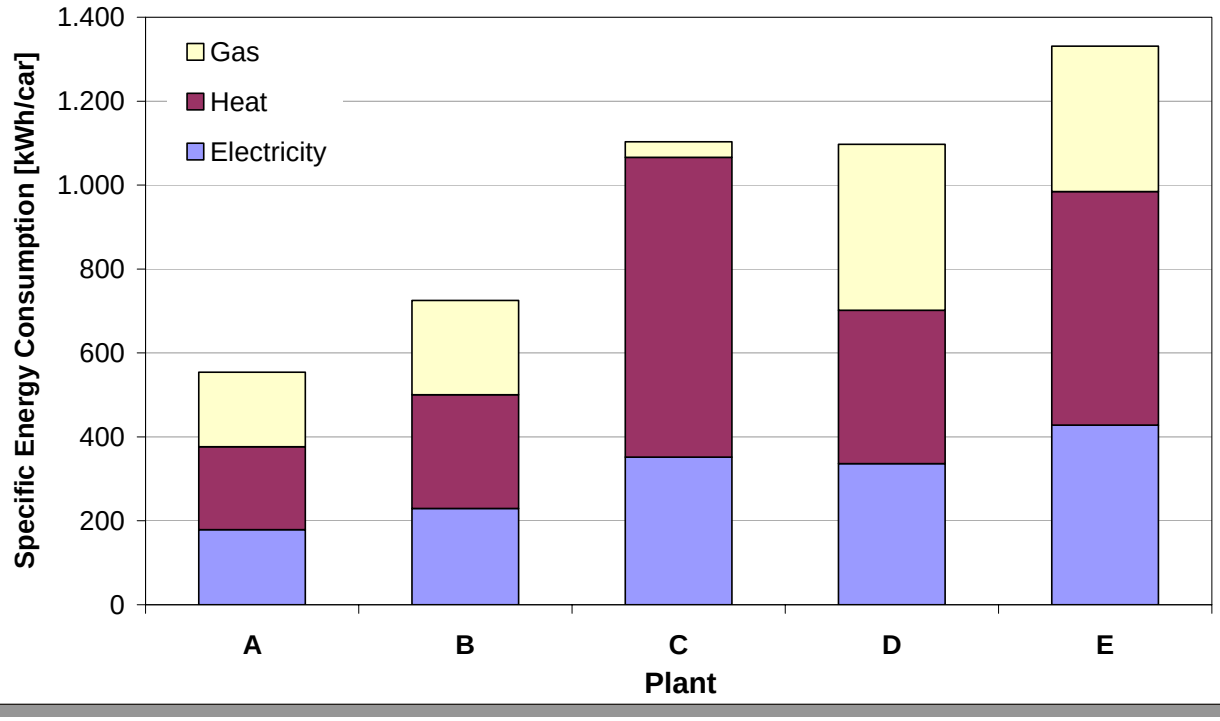
Example: Paint Shop



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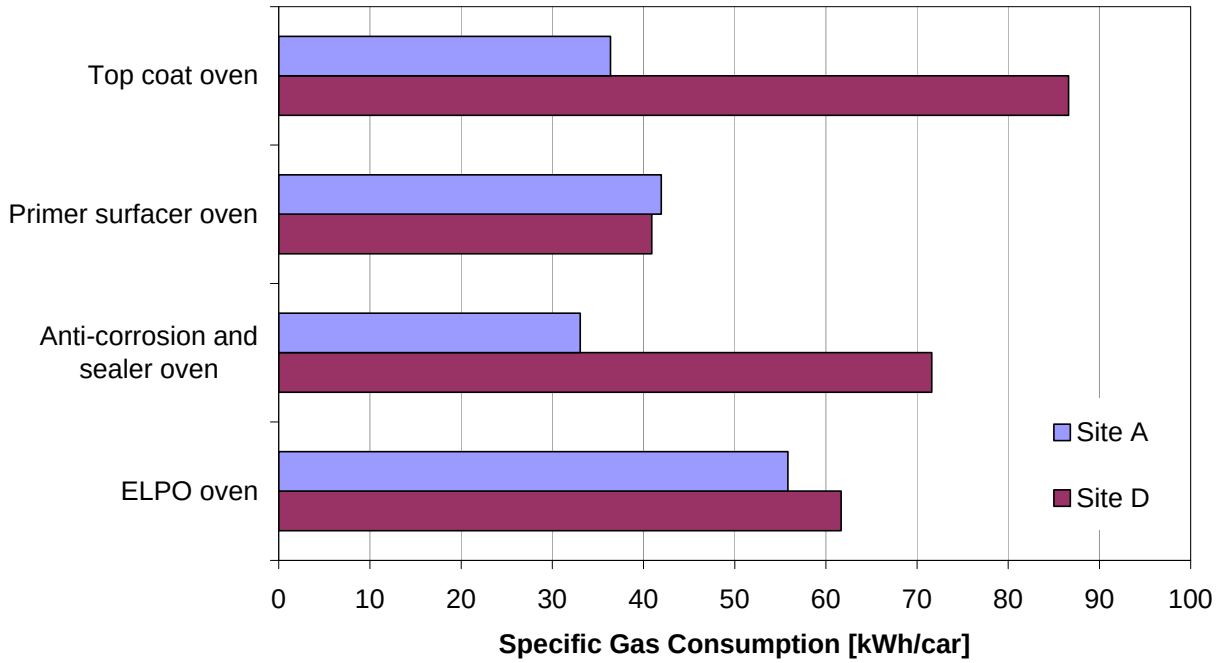
Example: Cure Ovens



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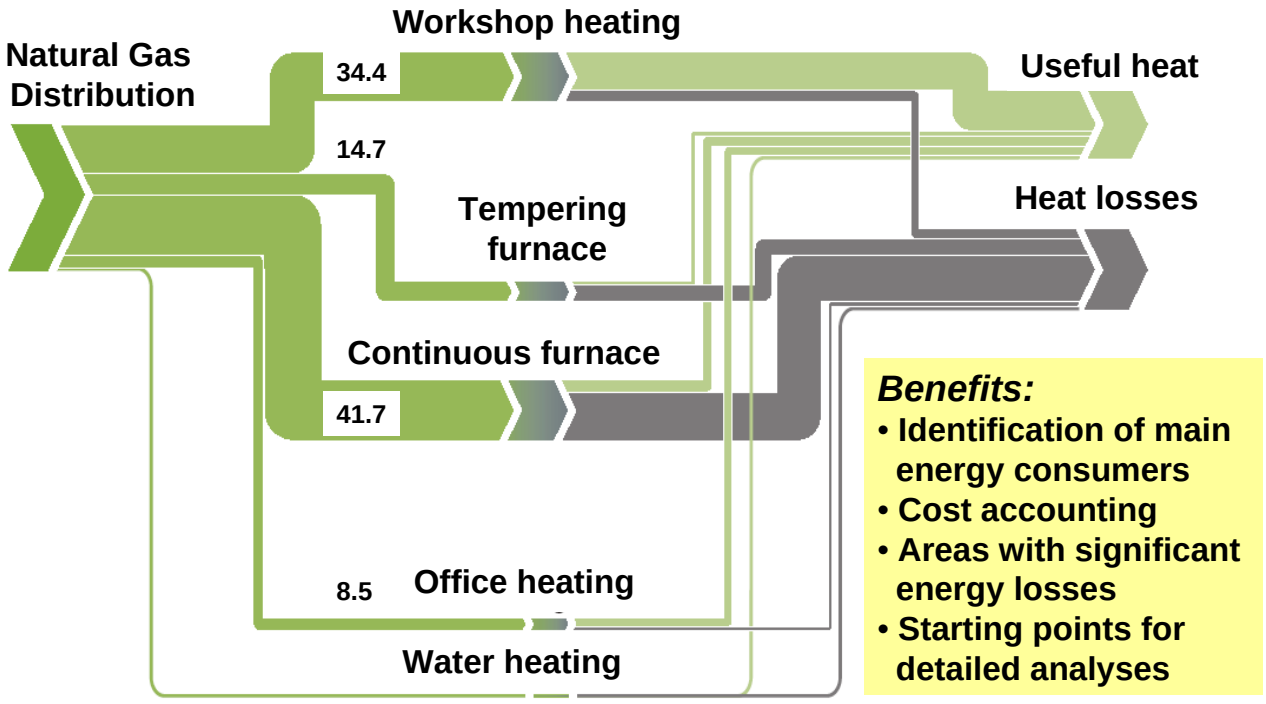
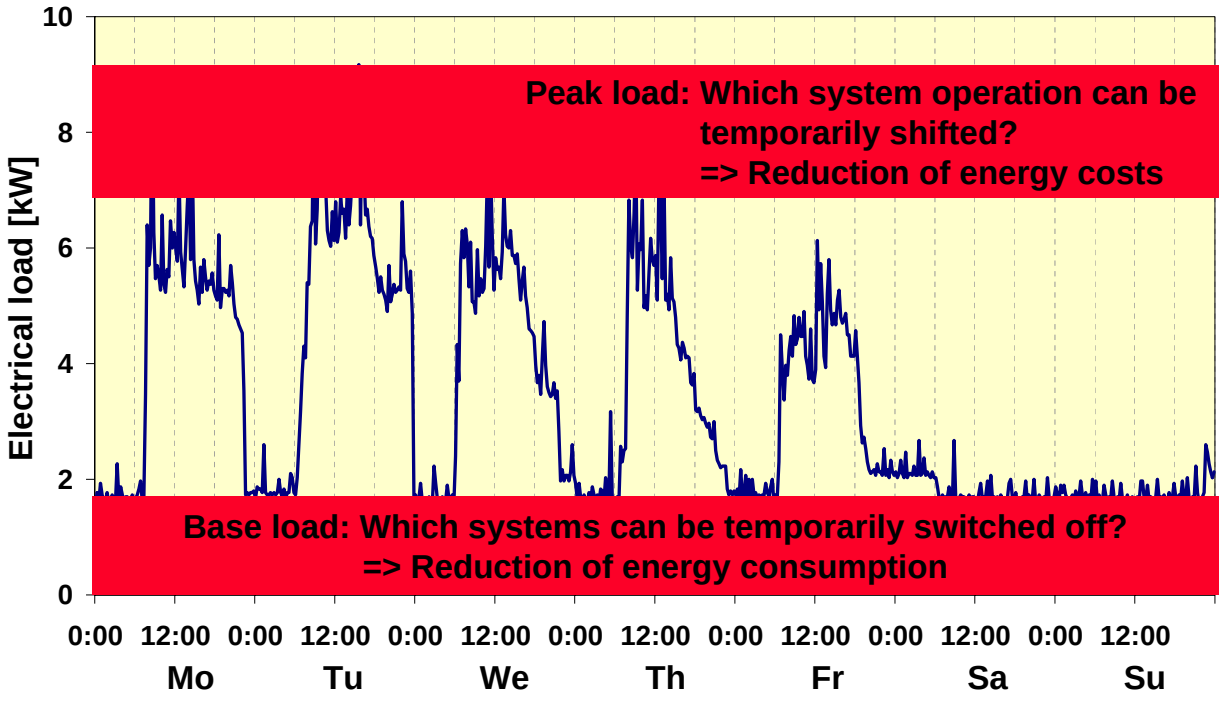
Sankey Diagram for a Metal Processing Enterprise



Benefits:

- **Identification of main energy consumers**
- **Cost accounting**
- **Areas with significant energy losses**
- **Starting points for detailed analyses**

Electric Load Curve of a Data Processing Center



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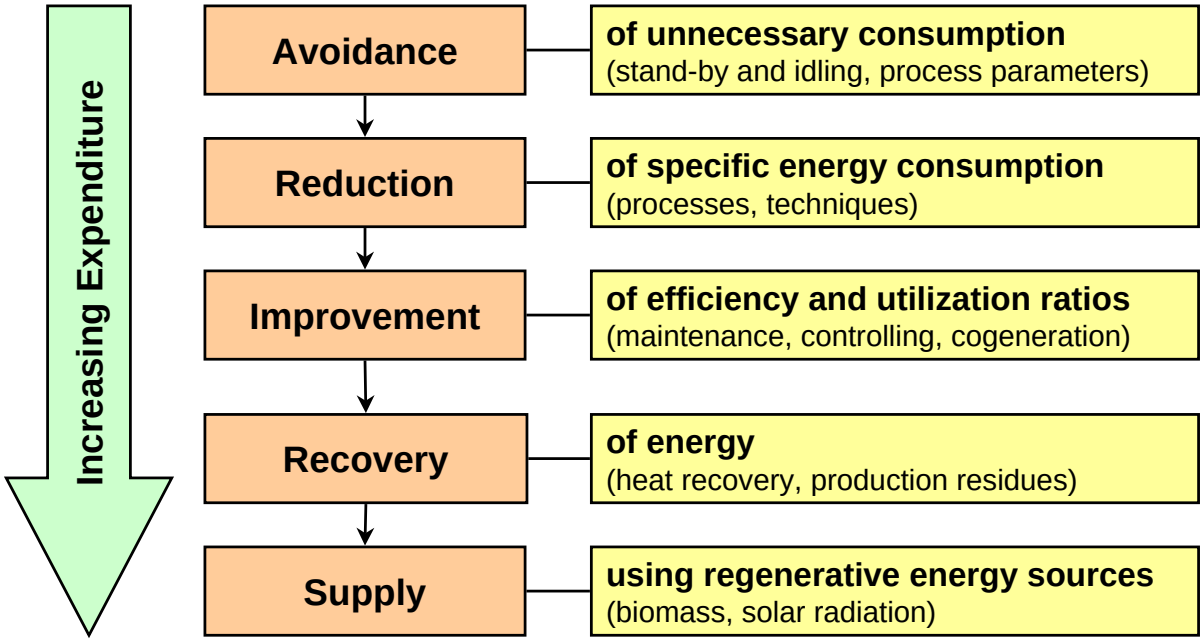
Proposals for Improved Energy Use



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Development of Overall Concepts – Example (1)

Kind of company: Production of electronic components
Initial situation: Heat supply by oil boiler
Reason for action: Extension of work shop

Leven, Schaefer 2004

Development of Overall Concepts – Example (2)

Measures

1. Supply of increased heat demand by additional
   a. Boiler with the same fuel
   b. Boiler with different fuel (e.g. gas or biomass)
   c. Heat pump
   d. Cogeneration unit (CHP)
2. Reduction of heat demand by
   a. Insulation
   b. Heat recovery from exhaust air
   c. Heat recovery from processes or compressed-air system

etc.

Concepts

- Concept 1:
  - Substitution of roof lights, modernization of the roof insulation (existing building)
  - Installation of a CHP unit
- Concept 2:
  - Integration of a CHP unit (No reductions of heat load)
- Concept 3:
  - Heat recovery from exhaust gases
  - Integration of a gas boiler (No reductions of heat load)

etc.

Assessment and Selection of Measures

- **Example:**
  Heat recovery from exhaust gases

- **Possible heat consumers**
  - **Hot water supply**
  - **Heating system**
  - **Air supply of building (outside air)**

- **Conventional approach vs. IER software tool**

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Assessment of Heat Recovery Measures

- Identification of a waste heat source
- Collection of information
- Site survey
- Measurements (e. g. load curve)
- Calculations
- Technical concept (i. e. feasibility)
- Profitability analysis
- Decision about realization

- **Disadvantage:**
  Highly time-consuming
  - **Assessment of several combinations of the waste heat source and possible heat sinks (consumers or networks)**
  - **Collection of information and analysis for every combination**

- **Standardized procedure for the approximate estimation of economical and technical aspects by applying a software tool**

Weber, Leven, Schaefer 2003

Assessment and Selection of Heat Recovery Measures

Waste heat source

- Medium
  - Flue gas from gas firing
  - Flue gas from oil firing
  - Flue gas from coal firing
  - Exhaust air
  - Compressed air
  - Oil
  - Water
- Flow rate, inlet temperature, minimum outlet temperature
- Time characteristic
  - Seasonal (yes or no)
  - Production (shifts per day)
  - Plant

Heat sinks

- Standardized
  - Air supply for buildings
  - Drinking water supply
  - Washers
  - Process heat network
  - Space heat network
- Time characteristic
  - Seasonal
  - Production
- Energy source
  - Natural gas
  - Hot water
  - Electricity
- Distance to waste heat source

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Output Data (Selection) - Output for Suitable Heat Sinks

- Technical
  - Transferable heat capacity [MW]
  - Useful operating time [h/a]
  - Transferable heat [MWh/a]
  - Demand of auxiliary energy [MWh/a]
- Economical
  - Annual cost savings [€/a]
  - Capital cost for heat exchangers, pipes, pumps etc. [€]
  - Payback period [a]
  - Internal rate of return [%]
  - Sensitivity analysis concerning energy prices
- Ecological
  - Reduction of CO_2 emissions [tons/a]
  - Reduction of primary energy demand [MJ/a]

Weber, Leven, Schaefer 2003

Result Sheet of a Consulting Report

Assessment criteria		Current situation	Measure 1	...
Energy	Electricity consumption [kWh/a] Fuel consumption [TJ/a] Peak load [kW] ... Specific electricity consumption [kWh_{el}/m^2a]	...	...	...
Economic efficiency	Energy supply costs [$/a] Energy cost savings [$/a] Investment [$] ... Specific energy costs [$/m²a]	...	...	...
Environment	Air pollutants [kg/a] GHG emissions [kg/a] ... Specific GHG emissions [kg/m²a]	...	...	...
Qualitative criteria	Reliability of supply Internal acceptance ...	...	...	...

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Energy Concepts – Content of a Consulting Report

- **Aims and Tasks**
- **Initial Situation**
- **Planned Modifications**
- **Comparison of Options**
  - **Economic assessment**
  - **Energy and CO_2 inventories**
- **Summary and Recommendations**
- **Appendices with essential Data and Assumptions**
  - **Energy prices**
  - **Economic life of equipment, interests**

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Summary

- **Energy Concepts for Enterprises**
  - **cover the procurement, conversion, distribution and utilization of energy**
  - **are based on a detailed analysis of the initial situation and planned modifications**
  - **should compare different options of measures and concepts**
- **Applicable Methodologies are**
  - **Energy characteristic (on different operational level)**
  - **Sankey diagrams and load curves**
- **Standardized Procedures and Software Tools**
  - **can significantly reduce time and costs**

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References

- Leven, B.; Schaefer, C.: ***Energy Concepts for Small and Medium-Sized Enterprises.*** Stuttgart: Ministry of Economics, 2004
- Leven, B.; Weber, C.: ***Energy Efficiency in Innovative Industries – Application and Benefits of Energy Indicators in the Automobile Industry.*** In: American Council for an Energy Efficient Economy: ACEEE-Summer Study on Energy Efficiency in Industry (Proceedings). Tarrytown, NY (USA) 24. - 27.07.2001
- Weber, C.; Leven, B.; Schaefer, C.: ***Methodology for cost effective assessment of heat recovery potentials.*** In: Proceedings of the Industry Workshop on Building Energy Performance Improvement through Advanced Technologies, Smart Organization and Financing. Chicago (USA): 7. – 8. 10. 2003
- Leven, B.: ***Energy Management in the Investment Goods Industry.*** Dissertation, to be published in 2004

- VDI guideline 3922: ***Energy Consulting for Industry and Business.*** Düsseldorf: VDI - The Association of Engineers, 1998
- VDI guideline 4661: ***Energetic characteristics - Definitions, terms, methodology.*** Düsseldorf: VDI - The Association of Engineers, 2003
- VDI guideline 3807: ***Characteristic values of energy consumption in buildings.*** Düsseldorf: VDI - The Association of Engineers, 1994

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